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None

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G2F
Selected US specifications from IPC sub-class G02F

(54) Image converter

(57) An image converter or scene simulator converts a projected visible image to an infra-red image through the heating effect of the visible light. The visible light is absorbed by an array of absorbent cells 1′ each of which is connected to a heat sink 3 by a thermally conductive post 5. The intensity distribution of the visible image is reproduced as a temperature distribution across the array of cells. Lateral heat spread is limited by reticulation of the array, giving high image resolution. Cell dimensions are typically of the order of tens of micrometres.

Fig.1(c).

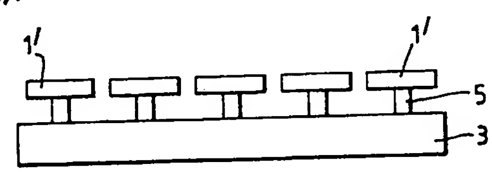

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Fig.1(a). PRIOR ART

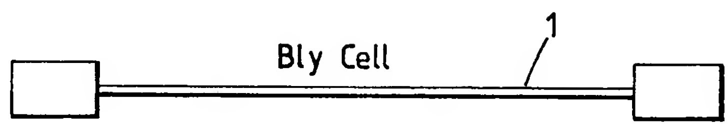


Fig.1(b).

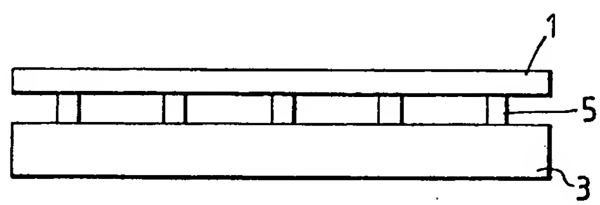


Fig.1(c).

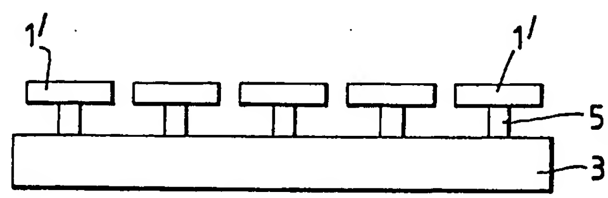


Fig.2(a).

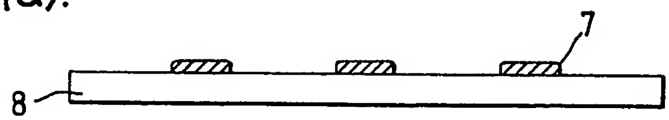


Fig.2(b).

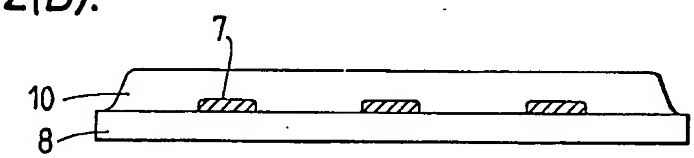


Fig.2(c).

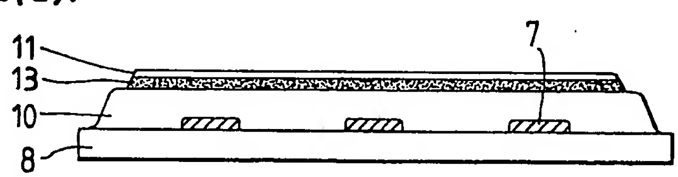


Fig.2(d).

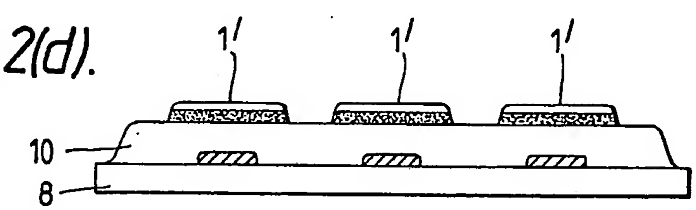


Fig. 2(e).

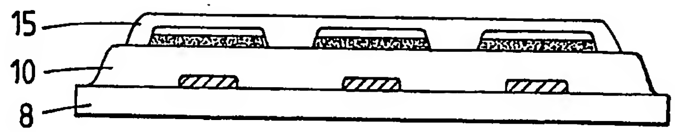


Fig. 2(f).

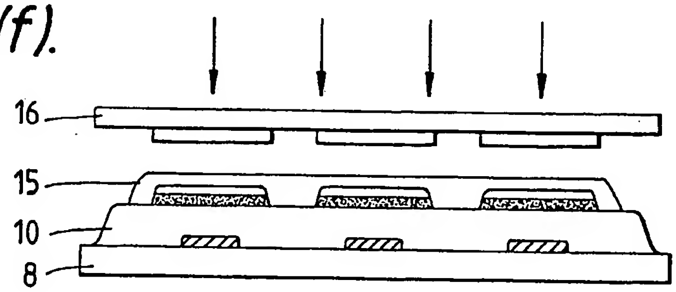


Fig. 2(g).

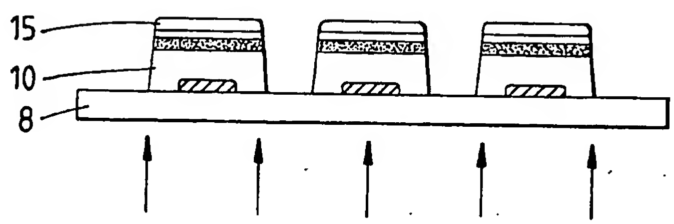
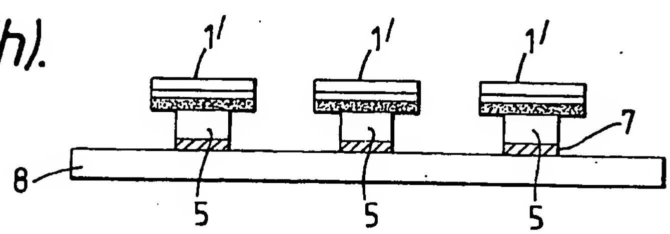


Fig. 2(h).



SPECIFICATION

Image converter

This invention relates to an image converter for converting an image in one waveband to an image in another waveband, and, in particular, but not exclusively for converting a visible image to an infra-red image.

Generation of infra-red images has been attempted in the past using a variety of optical and electrical devices. Common drawbacks of known techniques include poor resolution of the image, slow response time, high power input requirement and inconveniently large size. For many applications, therefore, where precision and small size are important, known systems are unsuitable.

An object of the present invention is to overcome or alleviate some of these drawbacks.

According to one aspect of the invention an image converter comprises an array of cells adapted to absorb incident radiation in a first waveband and to emit radiation in a second waveband and a corresponding array of thermally conductive means insulated from one another, arranged to connect each respective cell to a heat sink, the intensity of emission from each cell being dependent upon the intensity of the radiation incident upon that cell, the array thereby producing an image of varying intensity in said second waveband. Each cell may be defined simply as an area of a continuous surface local to a respective thermally conductive means but is preferably separated from adjacent cells by an insulating medium which may be air.

The first waveband may be in the visible region and the second waveband in the infra-red region. The cells are preferably substantially planar and the thermally conductive means may be thermally conductive posts. The cells may have a protective and/or anti-reflection coating.

According to another aspect of the invention a method of producing an image converter comprises the steps of providing a base arranged to act as a heat sink, fabricating pillars on said base, said pillars comprising a lower layer of thermally conductive material and an upper layer of material absorbent in a first waveband and emissive in a second waveband. The upper layer is preferably covered with a protective coating. The method may compris forming a pattern of metallic pads on said base to provide a mask on which said pillars are fabricated.

The method pr ferably uses monolithic techniques whereby continuous upper and lower layers are formed on the base, the pillars being fabricated by tching away material in said layers. The pillars are preferably formed by laser etching.

The upper layer is preferably anodised aluminium and the lower layer is preferably a polyimide material. The base may be quartz. The cross sectional area of the upper layer in the plane of the layers is preferably greater than that of the lower layer.

One embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, of which: Figure 1 shows the development from a Bly cell of an image converter in accordance with the invention; and Figure 2 shows in outline a method of manufacture of an image converter.

Figure 1(a) shows a known Bly cell which can be considered as the conceptual basis of this invention although our image converter and the technology associated with its construction represent a very considerable development beyond the basic Bly cell. The cell, originally designed by V.T. Bly, consists of a very thin membrane supported by its edges in an evacuable chamber (not shown). The membrane absorbs visible radiation, heats up and re-radiates infra-red in vacuum with a time constant determined by the membrane thickness. For rapid response to a changing input image, this time constant must of course be small. However to achieve a time constant even of 15 ms requires a membrane thickness of 400Å and for the shorter time constants required in certain applications the membrane would need to be considerably thinner. For a radiative area of any size this clearly presents major technical difficulties. The speed of response could be improved by convective cooling in an atmosphere but the thermal spreading this would introduce would be detrimental to image quality.

To reduce the time constant of the device our invention uses a Bly cell-type membrane 1 supported above a heat sink 3 on conductive posts 5 as shown in Figure 1(b). The membrane material absorbs effciently in the visible to near infra-red waveband and emits efficiently in the far infra-red waveband. The principal mechanism of heat transfer is now conduction to the heat sink, rather than radiation, which means the membrane cools more quickly. Of course the membrane should not cool so quickly that the infra-red image fades rapidly, but the provision of the posts 5 enables the rate of heat loss to be very precisely controlled by the particular choice of material and dimensions of the posts. A futher effect of introducing the heat sink is to decrease the effective pixel size. Heat generated in the basic radiative Bly cell of Figure 1(a) spreads sideways across the film, blurring the image. This effect is reduced by the posts 5 along which h at is preferentially c nducted because of the relatively low temperatur of the heat sink. Image resolution is therefore improved.

A further refinement which reduces pixel siz considerably mor is reticulation of the membran 1 as shown in Figure 1(c). The

membrane 1 is divided into a large number of small membranes or pixels 1′ positioned one atop each post 5.

The structure of the converter can be likened to a bed of nails, heads uppermost. The air gap between adjacent "nail heads", the pixels 1′, means that heat transference laterally across the array is minimal and a large array of extremely small pixels can give very high image resolution. An array 6cm × 3cm, for example, can contain 2000 × 1000 pixels. Time constants of a few milliseconds can be achieved with the "bed of nails" stucture. Low lateral heat spread removes the necessity for housing the converter in an evacuated chamber. The array is constructed using a monolithic fabrication process outlined n Figure 2. A pattern of aluminium pads 7 is deposited on a quartz or sapphire base 8 (Figure 2a). The pads 7 provide a self-aligning mask defining the location and diameter of the posts 5. This base is then spin coated with a "thick" substrate 10 of polyimide, and cured (Figure 2b). One suitable polyimide is Pyralin P2560 which has a low thermal conductivity of $0.0015Wcm^{-1}K^{-1}$. Other low conductvity plastics may also be used, for example PVC, ABS/polycarbonate or polyaryl sufone.

After the polyimide coating, an aluminium layer 11 is deposited and anodised (13), as in Figure 2c. The anodised surface 13 appears, as will be seen, on the lower face of the "nail heads" and provides, to a large extent, the absorptive property of the array. It is possible to increase this absorption if required.

The next stage is to define the nail heads or pixels 1, as shown in Figure 2d. This is done by etching with HF followed by H_3PO_4 : CH_3COOH : HNO_3. A thin protective coating 15 of the polyimide material is added and then finally, to improve absorption, an antireflection coating of a graded dielectric is applied over this polyimide layer.

Figures 2f-g show the laser milling process used to define the posts beneath the nail heads. The posts might typically be 5 μm high with diameter 10 μm. Etching plastics with excimer lasers gives uniformity of cut surfaces and high precision of the geometry. A quartz mask 16 is used while the polyimide between the pixels 1 is etched away from the upper face. In the laser milling of plastics, material is removed by scission of the long chain molecular structures. The upper side cut is carried out in a projection r proximity mode allowing transport of the volatile organic by-products of the milling process. By taking the cut right through to the base 8 a suitabl channel for the effluent is provided for the etch from the lower side.

Whilst this monolithic process is preferred for greatest possible uniformity of the devic , the array could equally be made in two parts and bonded together in a hybridisation process.

The embodiment described is designed for optimum efficiency in the conversion of visible to far infra-red (8-14 μm). The technique however is applicable to a range of wavebands, the regions of absorption and emission depending on the materials used and the temperature of operation. The bed of nails can easily be cooled to emit longer wavelenghs, useful, for example, for simulating space backgrounds for astronomical studies. For shorter wavelength emission, the bed must be heated, leading to a requirement for higher input powers and problems with radiative, as opposed to conductive, cooling. However, simulation in the 3-5μm band at least would be possible.

The input power required for the bed of nails converter can be controlled by the choice of materials and dimensions. For example, for the embodiment described the power input should be about 180W. A conventional cine projector is used to project an image onto the array at this power level, though other methods of focussing radiation onto the converter are of course also suitable. Similarly, a variety of imaging devices can be used to detect the emitted radiation. Whilst the fast response time of the converter makes it ideal for converting dynamic images, it could obviously also be used with static images.

CLAIMS

1. An image converter comprising an array of cells adapted to absorb incident radiation in a first waveband and to emit radiation in a second waveband and a corresponding array of thermally conductive means insulated from one another and arranged to connect each respective cell to a heat sink, the intensity of emission from each cell being dependent upon the intensity of the radiation incident upon that cell and the array thereby producing an image of varying intensity in said second waveband.

2. An image converter according to Claim 1 wherein said first and second wavebands are in the visible and the infra-red regions respectively.

3. An image converter according to Claim 1 or Claim 2 wherein each said cell is an area of a continuous surface local to respective thermally conductive means.

4. An image converter according to Claim 1 or 2 wherein adjacent cells are separated by an insulating medium.

5. An image converter according to Claim 4 wherein said insulating medium is air.

6. An image converter according to any prec ding claim wherein said cells have an antireflection coating.

7. An image conv rter according to any preceding claim wherein said cells have a pr tective plastic coating.

8. An image conv rter according to any preceding claim wherein said thermally conductive means comprise thermally conductive posts.

9. An image converter according to Claim 8 wherein said thermally conductive posts are mad of a polyimide.

10. An image converter according to any preceding claim wherein said heat sink is a quartz substrate.

11. An image converter according to any preceding claim wherein the pitch of said array is less than 100 microns.

12. An image converter according to any preceding claim wherein the pitch of said array is less than 40 microns.

13. A method of constructing an image converter comprising the steps of providing a base arranged to act as a heat sink, and fabricating pillars on said base, said pillars comprising a lower layer of thermally conductive material and an upper layer of material absorbent in a first waveband and emissive in a second waveband.

14. A method according to Claim 13 using monolithic techniques to form said upper and lower layers continuously on said base, said pillars being formed by etching the material in said layers.

15. A method according to Claim 14 wherein laser etching is used to form said pillars.

16. A method according to Claim 13 wherein said pillars are bonded to said base using hybridisation techniques.

17. A method according to any of Claims 13 to 16 wherein said upper layer is anodised aluminium.

18. A method according to any of Claims 13 to 17 wherein the cross sectional area of the upper layer in the plane of the layers is greater than that of the lower layer.

19. A method according to any of Claims 13 to 18 comprising the step of forming a pattern of metallic pads on said base to provide a mask on which said pillars are fabricated.

20. A method according to any of Claims 13 to 19 comprising the step of protectively coating said upper layer.

21. A method substantially as hereinbefore described with reference to the accompanying drawings.

22. An image converter substantially as hereinbefore described with reference to the accompanying drawings.

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